distance from one end to the other end of the feature in the longest direction, wheras the span or feature span length is in the shortest direction (that is not depth). The feature depth is the distance way from the main channel. For features with a nonuniform width (span), the span is the average span averaged over the run length.

[0132] The invention includes apparatus in which at least one section of the apparatus comprises surface features over more than 20% (preferably at least 40%, more preferably at least 70%) of a channel's surface (measured in cross-section perpendicular to length; i.e., perpendicular to the direction of net flow through the channel) in any channel segment, and preferably for a continuous stretch of at least 1 cm, in some embodiments surface features extend over a length of at least 5 cm. In the case of an enclosed channel, the surface % is the portion of a cross-section covered with surface features as compared to an enclosed channel that extends uniformly from either the base or the top of the surface feature or a constant value in-between. This later is defined as a flat channel. For example, if a channel had patterned top and bottom surfaces that were each 0.9 cm across (wide) and unpatterned side walls that were 0.1 cm high, then 90% of the channel's surface would comprise surface features.

[0133] In some embodiments, a device may contain essentially flat channels in a flow distribution section, where flow is internally manifolded into individual channels. The device may contain a heat transfer section that either may or may not have surface feature sections to enhance heat transfer. The device may also have a reaction section, where all or a part of the reaction section contains surface features. The surface features are best used in a cluster, where 5 or 10 or 20 or more similar features are continuously aligned (active surface feature groove followed by a ridge followed by an active surface feature and so on) to conduct a unit operation or to mix a stream comprising at least two fluids. The linear distance or distance along the ridges between surface features is preferably maintained between 0.01× the surface feature span or run width and 10× the surface feature span or run width. A preferred range for the distance between adjacent surface features is 0.2× to 3× the opening or span or run width of the active surface feature. As this distance increases, the otherwise laminar flow stream will relax to a conventional parabolic flow path and not readily induce fluid into the active surface features.

[0134] Preferably, the channel is enclosed on all sides, and in some embodiments the channel has a generally square or rectangular cross-section (in the case of rectangular channel, patterning is preferably disposed on both major faces). For a generally square or rectangular channel, the channel may be enclosed on only 2 or 3 sides and only the 2 or 3 walled sides are used in the above described calculation of % surface features.

Patterns

[0135] Each of the surface feature patterns may be repeated along one face of the main channel, with variable or regular spacing between the features in the main channel bulk flow direction. Some embodiments have only a single leg to each feature, while other embodiments have multiple legs (2, 3, or more). For a wide-width main channel, multiple features or columns of repeated features may be placed adjacent to one another across the width of the main channel. For each of the surface feature patterns, the feature depth, width, span, and spacing could be variable or constant as the pattern is repeated along the bulk flow direction in the main channel, although constant or regularly repeated dimensions are preferred. Also, surface feature geometries having an apex connecting two legs at different angles may have alternate embodiments in which the feature legs are not connected at the apex.

[0136] FIG. **2***e* shows a number of different patterns that may be used for surface features. These patterns are not intended to limit the invention, only to illustrate a few possibilities. As with any surface features, the patterns may be used in different axial or lateral sections of a microchannel.

[0137] In some embodiments (involving washcoating a catalyst composition onto a microchannel) it is desired to hold up liquid in the surface features in a gravitational field (i.e. in applications such as applying uniform coatings to the walls of microchannels). For such embodiments the vertical component (relative to gravity) of the run length of each surface feature leg should be preferably less than 4 mm and more preferably less than 2 mm to prevent the liquid in the feature from draining out. For these embodiments, it is also preferred for the active surface feature run width, span or opening to be less than the open channel gap of the microchannel (where draining and the main fluid flow occurs during the unit operation). If the run width is greater than the channel gap then the features may not hold the fluid during draining.

[0138] The surface feature geometry SFG-0 (see FIG. **3***a*) is described by an array of chevrons or v-shaped recesses that occur along the length of the unit operation process microchannel. The chevrons may be either regularly or irregularly spaced with equal or varying distance between successive features. Regular (or equal) spacing of the features may be preferred since the disruptions to the bulk flow in the main channel effected by the presence of each feature better reinforces the disruptions effected by the other features. A one-sided feature would have features on only one side of the microchannel. A two-sided feature would have features on two sides of a microchannel (either on opposite walls or adjacent walls). In some two-sided orientation embodiments, feature orientation may be either in the cis orientation or the trans orientation. In the cis orientation with features on opposite walls, shown in FIG. **3***a*, the features are a mirror image on both channel walls. Trans refers to an alignment of a two or more sided mirochannel with surface features where the features on opposite walls are not aligned, but rather a second wall is first taken as a mirror image and then rotated 180 degrees (so that the top view of the pattern appears upside down relative to the first wall) to create offsetting features. It is noted that the second and opposing wall may not be a perfectly rotated mirror image, as filler features may be added to create more net area of the microchannel that contains surface features, and since the features on opposite walls may be somewhat offset from one another along the direction of bulk flow. Flow orientation relative to the features on a given wall may be either cis A (flow direction from bottom to top of FIG. **3***a*) or cis B (for example, flow direction from top to bottom in FIG. **3***a*). Typically, the features are on opposing walls, but they could be on adjacent walls.

[0139] Cis A refers to an alignment of a two or more sided microchannel with surface features where the features on